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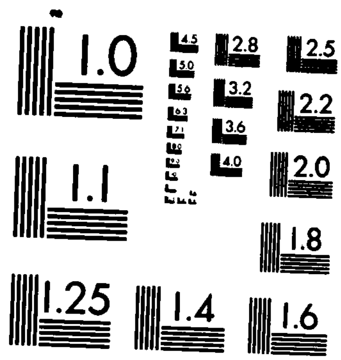
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The goal of the research contract has been to develop monolithic imaging antenna arrays for millimeter waves. This has required new developments in planar antennas for integrated-circuit substrates that are suitable for integration with planar Schottky diodes. In the future, this work should lead to a monolithic millimeter-wave TV camera.

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IMAGING ANTENNA ARRAYS

FINAL REPORT

DAVID RUTLEDGE

August 1, 1982 through September 30, 1985

US Army Research Office

Proposal 19483-EL

Contract DAAG29-82-K-0165

California Institute of Technology

Problem and Summary of Results

The goal of the research contract has been to develop monolithic imaging antenna arrays for millimeter waves. This has required new developments in planar antennas for integrated-circuit substrates that are suitable for integration with planar Schottky diodes. In the future, this work should lead to a monolithic millimeter-wave TV camera.

The key research papers published during the contract are the chapter, "Integrated-Circuit Antennas" in vol. 10 of the **Infrared and Millimeter Waves Series,** "Millimeter-Wave Monolithic Schottky Diode Imaging Arrays," **International Journal of Infrared and Millimeter Waves, 6,** pp. 981-997, and "Diode Grids for Electronic Beam Steering and Frequency Multiplications," to be published in the same journal.

The chapter, "Integrated-Circuit Antennas", investigates the effect of an integrated-circuit substrate on antennas and transmission lines. It is shown that antennas on substrates are frequently inefficient because of losses to substrate modes. It shows how this problem can be solved by putting a lens on the back side of the substrate. Transmission lines on thick substrates also suffer losses to substrate modes, and these losses are characterized theoretically and the predictions are verified experimentally. The chapter finishes by giving simple criteria for achieving diffraction-limited resolution in an imaging array by setting the spacing between antennas to satisfy the Nyquist sampling criterion, together with a simple bow-tie antenna design that achieves this resolution in millimeter-wave arrays.

The article, "Millimeter-Wave Monolithic Schottky Diode Imaging Arrays," describes a 90-GHz array of nine Schottky diodes with a DSB conversion loss of 11.2dB. This includes losses of 6.2dB in the optical system and the antenna. In the course of the work we developed a fabrication procedure for a monolithic Schottky diode with a 1.1THz zero-bias cutoff frequency, and a plastic quarter-wave matching layer for a silicon lens. Future work on the arrays will concentrate on developing antennas with higher efficiencies.

The final article, "Diode grids for Electronic-beam steering and Frequency Multiplication," makes a proposal for a diode grid to steer a beam electronically at 90GHz. The idea is to reflect the beam off of a grid of varactor diodes. The phase shift of the reflection at each point on the grid is controlled by the bias. The idea is that the beam can be steered if a progressive phase shift is given to the beam across the grid. Theoretical simulations indicate that this device should have a loss of 3dB at 90GHz. This work is the focus of our present contract from ARO.

Students supported who are candidates for the PhD degree:

Richard Compton
Wyman Williams
Dayalan Kasilingam
Wayne Lam

Students supported who have been granted a PhD degree:

Dean Neikirk - now an assistant professor at the University of Texas, working on millimeter-wave devices.
Peter Tong - now working at the Hewlett-Packard Company on millimeter-wave devices.
Chung-en Zah - working at the Bell Communications Research Labs in optical communications.

Army contacts:

Delivered imaging array to Richard Hartmann's group at the Redstone Arsenal.
Delivered imaging array to Paul Claspy's group at Case Western.
Visited by James Mink and Felix Schwering to discuss this contract, July, 1985.
Consulted for Richard Shurtz, Night Vision Laboratory, on infrared filters and uncooled detectors.
Near-millimeter-wave communications workshop, Long Island, New York, December 1984.

Journal and Conference Papers

"Surface-Wave Losses of Coplanar Transmission Lines," with D. P. Kasilingam, Int. Microwave Symp., Boston, June 1983.

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"Integrated-Circuit Antennas," with N. G. Alexopoulos, **IEEE Electrotechnology Review**, pp. 44, 1985.

"Near-Millimeter Wave Imaging Arrays," with R. C. Compton, C. E. Zah and N. C. Luhmann, Jr., URSI meeting, Vancouver, Canada, June, 1985.

"Circuit Modeling of Planar Meshes with Discrete Loads," with R. C. Compton, SPIE Symposium on Optical and Electro-Optical Engineering, San Diego, August 1985.

"Diode Grids for Millimeter-Wave Beam Steering and High-Power Frequency Multiplication," with Wayne W. Lam, Christina F. Jou, and N. C. Luhmann, Jr., 1985 Allerton Symposium on Antenna Applications, Monticello, Illinois.

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